

Lung Cancer:

Causes and Prevention

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CHAPTER 7

The Causes of Lung Cancer in Texas

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ABSTRACT

A population-based case-comparison interview study of lung cancer was conducted from 1979 to 1982 in six Texas coastal counties—Orange, Jefferson, Chambers, Harris, Galveston, and Brazoria—to evaluate the association of lung cancer with occupational and other environmental exposures. Lung cancer mortality rates in these counties consistently have exceeded lung cancer mortality rates observed for Texas and the United States from 1950–1969 to 1970–1975 for both sexes and races (white and nonwhites).

Histologically and cytologically confirmed incident cases diagnosed during the interval July 1976 to June 1980 among white male and female residents aged 30–79 years were ascertained from participating hospitals in the six-county area. Both population-based and decedent comparisons were selected and matched on age, race, sex, region of residence, and vital status at time of ascertainment.

The exposures of primary interest in the study of lung cancer are those associated with occupation (employment in specific industries and occupations) in conjunction with tobacco, alcohol, diet, and residential exposures.

Key Words: Smoking history, petrochemical industry, histologic types, construction workers, chemical manufacturing, transportation

Introduction and Background

Data presented by Doll and Peto (1) and related reports (2) indicate that respiratory cancer sites, dominated by lung cancer, show the most dramatic increases of all cancer sites over the past 30 years. The role of smoking in the etiology of respiratory cancer has been well documented. In addition, lung cancer is

recognized as possibly the most important work-related cancer. However, the interaction between smoking and occupational exposures and the increased risk that may be attributed to an occupational exposure has not been very well characterized for a large number of workplace exposures.

A population-based case-comparison interview study of lung cancer, obtaining detailed occupational histories, was conducted in six Texas coastal counties where lung cancer mortality rates were elevated (3). Figure 1 shows the location of the counties of Orange, Jefferson, Chambers, Brazoria, Galveston, and Harris, a highly industrialized area where Houston is located. Approximately 25% (3.5 million) of the total state population in 1980 resided in this southeastern coastal area, the majority (77.5%) in Harris County.

Newly diagnosed, histologically confirmed cases of lung cancer in white females (including Hispanic) were ascertained from July 1977 through June 1980 in Harris County (3 years) and from July 1976 through June 1980 for the surrounding five counties. Similarly, cases among white males (including Hispanic) were ascertained for four years (July 1976 through June 1980) for the five less urban but industrialized counties, excluding Harris County. Background lung cancer mortality rates for white males and females were examined by Texas State Economic Area

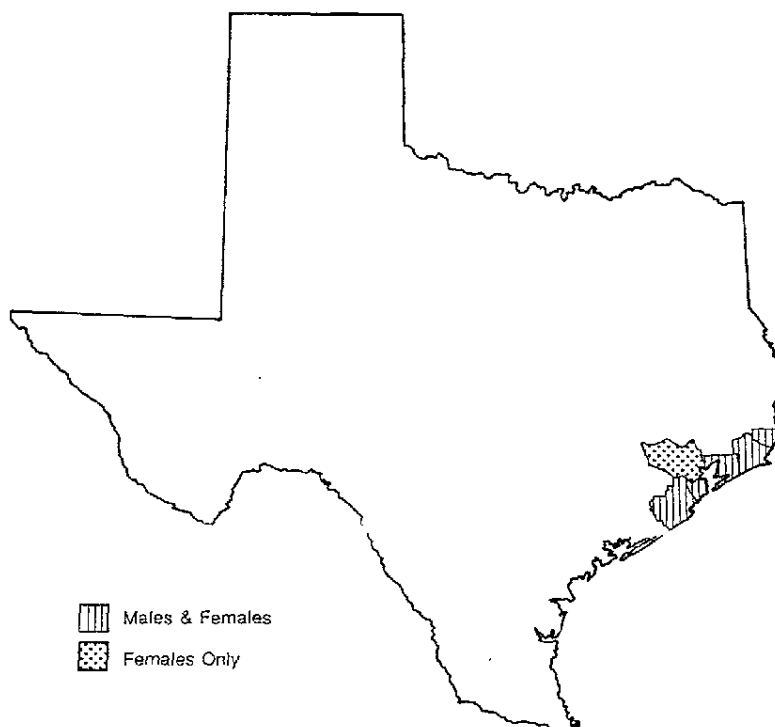


Figure 1. Texas lung cancer study area.

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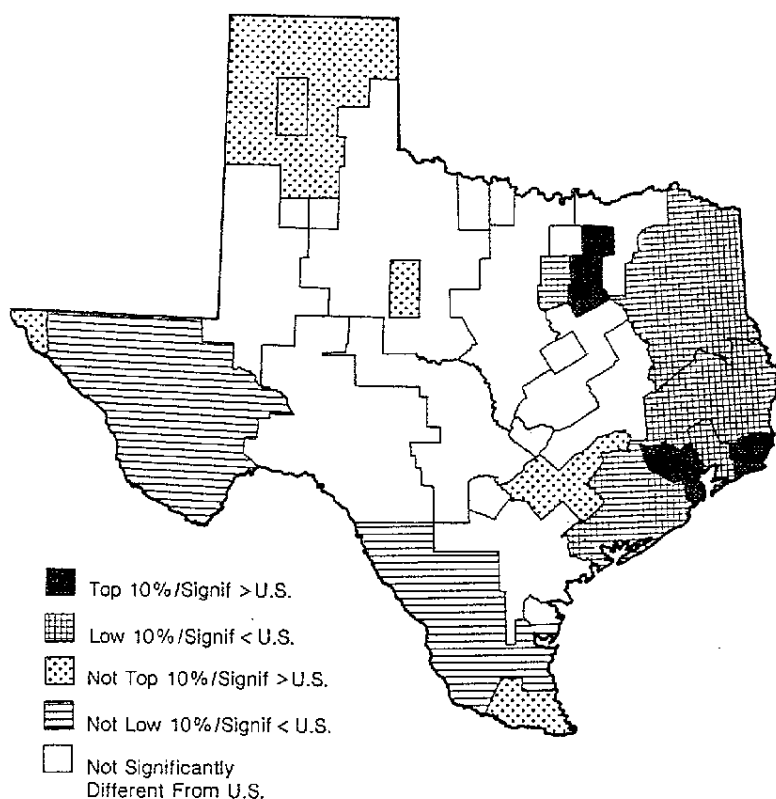


Figure 2. Lung cancer mortality 1970-1975 for white males.

(SEA) for the time period (1970 to 1975¹) immediately preceeding the case-comparison study. As shown in Figures 2 and 3, these maps consistently document the significantly higher lung cancer mortality rates observed earlier for both white males and white females in these Texas coastal counties. The dark areas along the upper Texas coast are the Beaumont SEA (Orange and Jefferson counties), the Houston SEA (Harris County), and the Galveston SEA (Galveston County). Age-adjusted mortality rates (adjusted to the 1960 United States population) in these areas are in the top 10% of rates for SEAs in the United States and are significantly higher than the white male or white female lung cancer mortality rate for the total United States population. For white females in Harris County, this excess was notable for both the rate and the trend in the rate from 1950 to 1975 (4). For all ages, combined, the overall excess in lung cancer mortality in the Texas study area is approximately 30-40%, but this is considerably greater for some age groups.

Occupational and industrial exposures of importance for residents of the Texas coastal area include those associated with shipbuilding and repair, chemical and

¹Excluding deaths for 1972.

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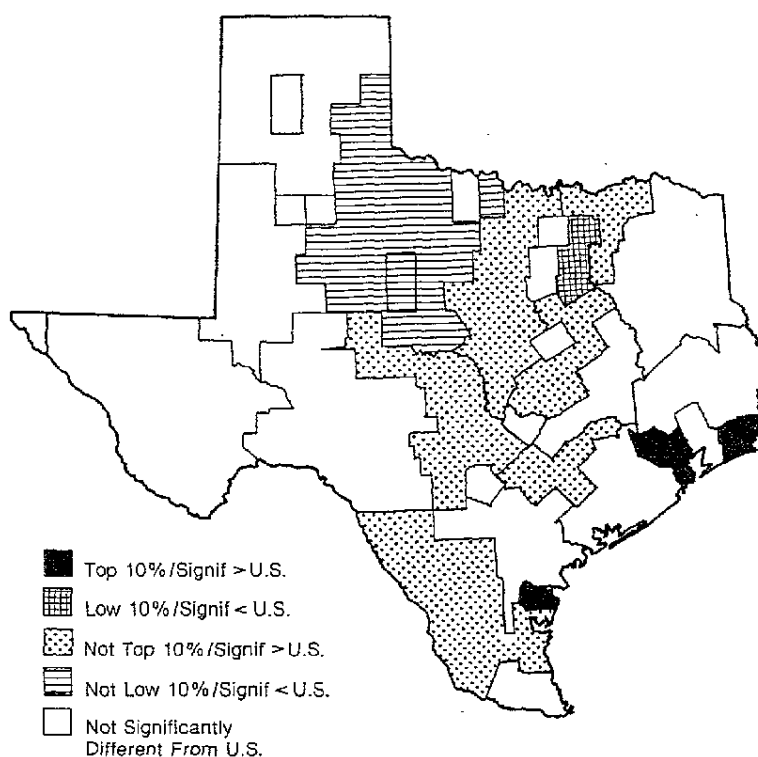


Figure 3. Lung cancer mortality 1970-1975 for white females.

petrochemical manufacturing, petroleum refining, construction, and metal industries. The largest United States based chemical and synthetic rubber production facilities are located in the study area, so a high proportion of the working population currently is employed or has been employed in these industries. For some of the smaller counties, such as Orange and Jefferson, where a single industry is dominant, as high as 27% of the working population reported being currently employed in chemical and allied products manufacturing compared with 2% for Harris County (5).

Methods

Histologically confirmed incident cases of lung cancer diagnosed among white male and female residents (including Hispanic) of the study counties for the designated time intervals (July 1977 through June 1980 for females in Harris County and July 1976 through June 1980 for males and females in other counties) were ascertained by review of hospital and state records. Hospitals in the study area that were not already participating in the Statewide Cancer Reporting Program

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were contacted and asked to participate in the study. Population-based and decedent comparison subjects were selected from state and federal records and matched to cases on age, race, sex, vital status at time of ascertainment, and county of residence (Harris County or other five counties). Hispanic study subjects were identified systematically by use of an algorithm to identify Spanish surname. Medical records were abstracted by state-trained abstractors to obtain relevant disease and demographic data. Following contact with the family physician (for cases only), personal interviews were conducted with study subjects or with the next of kin of decedent cases and comparison subjects, using established criteria for selecting the most appropriate next of kin respondents. Interviews were conducted by trained interviewers in the home using a standardized interview protocol. Detailed information regarding the primary exposures of interest was collected, specifically smoking history, work history, residential history, and drinking history.

Industries of employment were coded to the Standard Industrial Classification (SIC) (6) and occupations were coded using the *Dictionary of Occupational Titles* (7). The Mantel-Haenszel summary chi-square and odds ratio statistics were calculated (8). Confidence intervals (95%) were calculated using the method of Miettinen (9).

Results

A total of 56 of the 67 hospitals in the six-county Texas study participated in the study, including all of the seven large hospitals (500 or more beds). Ten of the 11 smaller hospitals that did not participate were located in Harris County. Therefore we were able to ascertain 92.2% (1520 cases) of the total 1649 incident white male and female lung cancer cases (including Hispanic) estimated for the 3- to 4-year interval (mid-1976 or 1977 to mid-1980). The number of incident cases was estimated by adjusting age-race-sex-county mortality rates by population growth and an incidence: mortality ratio of 1.35:1.0. Case ascertainment was higher for residents of counties other than Harris County, 97.2% vs 82.1% (Table 1). A total of 766 female and 754 male cases were ascertained representing, respectively, 88.7 and 96.1% of the total estimated incident cases ascertained. Hispanic females appear to be poorly ascertained (38.1%), but this may be related to the classification based on Spanish surname which may not be an effective technique for ascertaining married Hispanic females.

All ascertained cases will be used for determining age-race-sex and county lung cancer incidence rates for the study area. A total of 88.9% of the ascertained cases were included in the interview study. Some cases (110, or 7.2%) lacked histologic or cytologic confirmation of lung cancer and were ineligible for the case-comparison study. For the majority of these cases (79, or 71.8%) the basis of the lung cancer diagnosis was radiologic or clinical evidence. There was insufficient diagnostic information available on the remaining 31 cases. Additional losses of study subjects in the case-comparison study were related to race and residential eligibility criteria; unable to locate; moved out of interview area; physician,

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Table 1. Lung cancer case ascertainment in Texas study by sex, ethnic group, and area, 1976-1980

	Number estimated	Number ascertained ^a (%)	Number cases interviewed ^b
White Females			
Anglo	822	750 (91.2)	449
Spanish surname	42	16 (38.1)	11
Total	864	766 (88.7)	460
White Males			
Anglo	767	730 (95.2)	460
Spanish surname	18	24 (133.3)	15
Total	785	754 (96.1)	475
Area			
Harris County (females only, 1977-1980)	567	468 (82.1)	275
Other counties	1082	1052 (97.2)	660
Total	1649	1520 (92.2)	935

^aIncludes 110 cases without histologic confirmation and an additional 15 cases estimated to be ineligible, in terms of race and residence criteria.

^bExcludes cases ineligible; not located; refusals by physician, hospital, or study subject; and cases interviewed and subsequently identified as ineligible, or data to be of poor quality.

Table 2. Texas lung cancer study population by sex, study group, and ethnicity

	Study group		Totals
	Cases	Controls	
Total			
Female	460	482	942
Male	475	466	941
Total	935	948	1883
Spanish surname			
Female	11	20	31
Male	15	19	34
Total	26	39	65

hospital, and subject refusals; and poor quality interview data. Overall study subject refusal rates were 7.7% and 10.7% for decedent cases and controls respectively, and 13.5% and 20.6% for living cases and controls, respectively. A total of 935 interviews was completed with eligible cases (460 females and 475 males) and 948 interviews with frequency matched comparison subjects (Table 2). Included in these totals are 26 Spanish surname cases and 39 comparison subjects. Separate analyses are not presented at this time for these study subjects.

The average duration of time study subjects resided in the county of diagnosis or in the six-county study area is over 25 years for all study groups. The majority of both male (86%) and female (82%) cases were decedent cases and were slightly older at time of diagnosis than the living cases (Tables 3 and 4). The distribution of age at diagnosis is compared for male and female study groups in Figure 4. A higher proportion of the female cases was diagnosed before age 60 (45.4%) than male cases diagnosed before age 60 (34%).

Age at diagnosis (years)

30-39
40-49
50-59
60-69
70-79 +

Totals

Age at diagnosis (years)

30-39
40-49
50-59
60-69
70-79 +

Totals

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Table 3. Number and percentage of male lung cancer cases by age at diagnosis and type of respondent, Texas, 1976 to 1980

Age at diagnosis (years)	Type of respondent								Total			
	Self				Next of kin							
	Cases		Controls		Cases		Controls		Cases		Controls	
	No	%	No	%	No	%	No	%	No	%	No	%
30-39	1	1.5	1	1.6	3	0.7	2	0.5	4	0.8	3	0.6
40-49	5	7.5	7	10.9	28	6.9	34	8.5	33	7.0	41	8.8
50-59	23	34.3	22	34.4	102	25.0	98	24.4	125	26.2	120	25.7
60-69	31	47.0	23	35.9	165	40.4	164	40.8	196	41.3	18.7	40.2
70-79 +	7	10.6	11	17.2	110	27.0	104	25.9	117	24.7	11.5	24.7
Totals	67	100.0	64	100.0	408	100.0	402	100.0	475	100.0	466	100.0

Table 4. Number and percentage of female lung cancer cases by age at diagnosis and type of respondent, Texas, 1976 to 1980

Age at diagnosis (years)	Type of respondent								Total			
	Self				Next of kin							
	Cases		Controls		Cases		Controls		Cases		Controls	
	No	%	No	%	No	%	No	%	No	%	No	%
30-39	0	0.0	3	2.6	6	1.6	5	1.4	6	1.3	8	1.7
40-49	9	11.1	12	10.3	40	10.6	50	13.7	49	10.6	62	12.9
50-59	36	44.4	55	47.4	118	31.1	104	28.4	154	33.5	159	33.0
60-69	24	29.6	34	29.3	153	40.4	135	36.9	177	38.5	169	35.1
70-79 +	12	14.8	12	10.3	62	16.4	72	19.7	74	16.1	84	17.4
Totals	81	100.0	116	100.0	379	100.0	366	100.0	460	100.0	482	100.0

Proportions of male and female cases and comparison subjects using tobacco, cigarettes, alcohol, or who "ever lived with household member who smoked regularly" are compared in Table 5. Ninety-seven percent of the male cases and 91% of the female cases reported ever smoking cigarettes but a higher proportion of the female than male cases reported smoking cigarettes currently, 68% vs 54%. Proportions of heavy smokers and use of alcohol (ever) were higher for cases than comparison subjects and for males than females. An extremely high proportion of both female cases and comparison subjects report having lived with a household member who smoked regularly, 93% vs 88%.

Although the patterns of risk differed for males and females (Table 6), the odds ratios for all smoking variables were statistically significant at the $p = .05$ level. Among males, ex-smokers had a risk higher than current smokers, whereas in females the risk was lower in ex-smokers. The highest odds ratio for females was observed for current smokers, 7.9 vs 5.0 for ex-smokers. Odds ratios for the ac-

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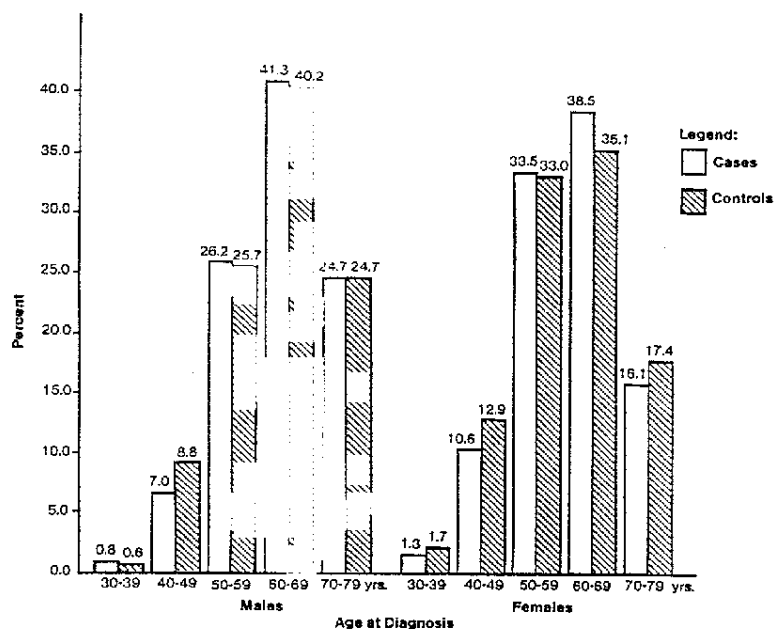


Figure 4. Age distribution (age at diagnosis) for male and female study subjects, Texas lung cancer study, 1976-1980. Clear columns, cases; shaded columns, controls.

cumulated lifetime cigarette dose, expressed as pack-years, were higher for males in the low and moderate categories but associated with a similar gradient in both males and females. No difference in risk was associated with the use of filtered cigarettes for either males or females.

The role of "passive smoking" in contributing to risk of lung cancer was examined (Table 7). In this analysis the crude (or unadjusted) odds ratio are increased and significant for both males and females, 1.4 and 2.1, respectively. However, when the confounding effect of individual subject smoking was controlled by stratifying the

Table 5. Proportion of cases and controls reporting use of tobacco, cigarettes and alcohol by sex, Texas lung cancer study, 1976-1980

	Males		Females	
	Cases	Controls	Cases	Controls
Tobacco (ever)	0.99	0.90	0.91	0.59
Cigarettes (ever)	0.97	0.80	0.91	0.59
Cigarettes (current)	0.54	0.47	0.68	0.38
Cigarettes (light)	0.08	0.10	0.08	0.17
Cigarettes (heavy)	0.45	0.29	0.34	0.13
Alcohol (ever)	0.86	0.81	0.78	0.63
Lived with a smoker	0.76	0.70	0.93	0.88

Table 6. Odds ratios^a associated with smoking variables for males and females, Texas lung cancer study, 1976-1980

	Males	Females
Ever smoked	10.12	6.89
Current smoker	9.59	7.89
Ex-smoker	10.85	5.00
Pack-years		
Low (0-35)	6.24	3.21
Moderate (36-63)	9.39	7.98
High (64+)	13.05	13.35
Filtered cigarettes		
Yes	9.39	7.11
No	10.25	6.06
Both	12.27	7.09

^aAll odds ratios significant at $p < .05$.

male and female study groups into smokers (ever) and nonsmokers (never) and examining the adjusted odds ratios, there was no significant increase in risk associated with passive smoking. In fact, the odds ratios for nonsmokers living with a regular smoker were not increased for either males or females, 0.52 and 0.78, respectively. However, odds ratios for smokers living with a regular smoker were increased, although not significantly, 1.28 and 1.80 for males and females. The overall odds ratios (adjusted) associated with passive smoking were only slightly increased and not significant for either males or females, 1.2 and 1.3, respectively. When the possibility of a "passive smoking" effect was examined among nonsmokers by number of years lived with a regular smoker, there was very little difference in risk for females who lived with a regular smoker for 0-32 years (Table 8). The odds ratios for males suggest an increase by are based on smaller numbers than the analysis in females.

Table 7. Odds ratios for passive smoking (household member smoked regularly) in Texas male and female lung cancer studies, 1976-1980

	Yes		No		Odds ratio	95% Confidence interval	χ^2
	Case	Control	Case	Control			
Males							
Crude	363	329	93	119	1.41 ^a	1.04, 1.92	4.8
Self ever smoked							
No	5	56	6	34	0.52	0.15, 1.74	1.2
Yes	357	273	87	85	1.28	0.91, 1.79	2.0
Overall (MOR)					1.20	0.87, 1.65	1.18
Females							
Crude	429	425	24	51	2.12 ^a	1.29, 3.50	9.05
Self ever smoked							
No	33	164	8	32	0.78	0.34, 1.81	0.3
Yes	396	260	16	19	1.80	0.92, 3.58	3.0
Overall (MOR)					1.30	0.78, 2.18	1.0

^a $p < .05$.

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Table 8. Odds ratios associated with passive smoking

Ever live with household member who smoked	Number	Odds ratio	Confidence interval	χ^2
Males				
Total nonsmokers	61	0.52	0.15, 1.74	1.2
0-32 years	49	0.40	0.10, 1.58	1.8
33+ years	10	1.56	0.30, 8.05	0.3
Females				
Total nonsmokers	201	0.78	0.34, 1.81	0.3
0-32 years	97	0.62	0.24, 1.63	0.9
33+ years	99	0.93	0.38, 2.28	0.0

Histologic types of lung cancer were classified according to the World Health Organization (WHO) classification (10). The four major cell types account for 75-85% of the cases in both the male and female series and the cell type distribution by age group is shown for males and females in Table 9. Adenocarcinoma is the predominant lung cancer cell type in both young (30-49 years) males and females, comprising 37.8% (males) and 38.9% (females) of all lung cancers among persons aged 30-49 years at diagnosis. There is a marked shift with age in this pattern such that for both males and females aged 70 or older at diagnosis the predominant cell type is squamous or epidermoid (accounting for 40.5% of all cases among males and 31.0% among females). Overall, squamous was the predominant cell type among males (42.2%) and adenocarcinoma among females (35.5%). These patterns held for both smokers and nonsmokers except for nonsmoking males, in whom 6 of 11 (54.5%) cases were adenocarcinoma.

The risk associated with smoking was examined by cell type, specifically odds ratios for smoking categories within the adenocarcinoma series compared with nonadenocarcinoma cases (Tables 10 and 11). The odds ratios for smoking categories based on pack-years were all significant, emphasizing the increased risk of lung cancer (all types) associated with smoking. However, the gradient of risk, in both males and females, was markedly different for adenocarcinoma compared with nonadenocarcinoma (all other lung cancer) cell types. There were 104 cases of

Table 9. Male and female lung cancer cases by histologic type and age, Texas, 1976-1980

Cell type	Males						Females					
	30-49 years		50-69 years		70+ years		30-49 years		50-69 years		70+ years	
	No	%	No	%	No	%	No	%	No	%	No	%
Squamous	8	21.6	112	34.8	47	40.5	11	20.4	74	22.6	22	31.0
Small cell	4	10.8	64	20.1	16	13.8	10	18.5	92	28.1	11	15.5
Adenocarcinoma	14	37.8	73	22.9	17	14.7	21	38.9	99	30.3	19	26.8
Large cell	2	5.4	19	6.0	9	7.8	4	7.4	11	3.4	3	4.2
Other		24.4		16.2		23.2		14.8		15.7		12.5
Total		100.0		100.0		100.0		100.0		100.0		100.0

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Table 10. Odds ratios associated with smoking for lung cancer cell types in males, Texas lung cancer study, 1976-1980

Cell type	Smoking category (pack-years)	Odds ratio	Confidence intervals	χ^2
Adenocarcinoma	Low	3.85	1.44, 10.31	8.04
	Moderate	4.45	1.72, 11.48	10.93
	High	5.38	2.14, 13.56	15.21
Nonadenocarcinoma	Low	6.60	2.75, 15.84	21.57
	Moderate	11.30	4.87, 26.19	43.75
	High	15.41	6.73, 35.25	63.34

Table 11. Odds ratios associated with smoking for lung cancer cell types in females, Texas lung cancer study, 1976-1980

Cell type	Smoking category (pack-years)	Odds ratio	Confidence intervals	χ^2
Adenocarcinoma	Low	2.16	1.18, 3.98	6.37
	Moderate	4.32	2.40, 7.79	26.11
	High	7.80	4.28, 14.20	52.93
Nonadenocarcinoma	Low	4.17	2.34, 7.43	25.80
	Moderate	10.97	6.27, 19.20	86.87
	High	18.90	10.61, 33.67	128.13

adenocarcinoma in the male series and 139 in the female series. A much steeper increase in risk associated with lifetime cigarette dose (pack-years) is observed for all other lung cancer cell types compared to adenocarcinoma. These patterns are summarized in Figure 5.

Preliminary analyses of the detailed work histories is based on the usual occupation and usual industry of employment as reported or as summarized from the work history for self and spouse. Examination of the work histories indicates that approximately 78% of the study subjects spent more than half of their reported working time employed in the occupation reported as their usual occupation. Usual industry of employment was determined by selecting the industry in which a subject was reported to have been employed for the longest duration of time. Odds ratios, adjusted for smoking (ever/never) were determined to identify whether an increased risk was associated with employment in a given occupation or industry for both males and females. Using the Professional/Technical category as a referent for males (odds ratio = 1), none of the odds ratios for the other occupational categories was significantly increased (Table 12). Odds ratios (OR) for usual industry of employment were similarly calculated using the sales category (SIC 50-59) as the referent (OR = 1.0) (Table 13). Significantly elevated odds ratios were observed for several industrial categories, specifically construction (SIC 15-17), chemical manufacturing (SIC 28), metal manufacturing (SIC 33-34), and transportation (SIC 40-49). In addition, an elevated odds ratio (OR = 2.44) of borderline statistical significance (at the .05 level) is observed for oil and gas extraction (SIC 13).

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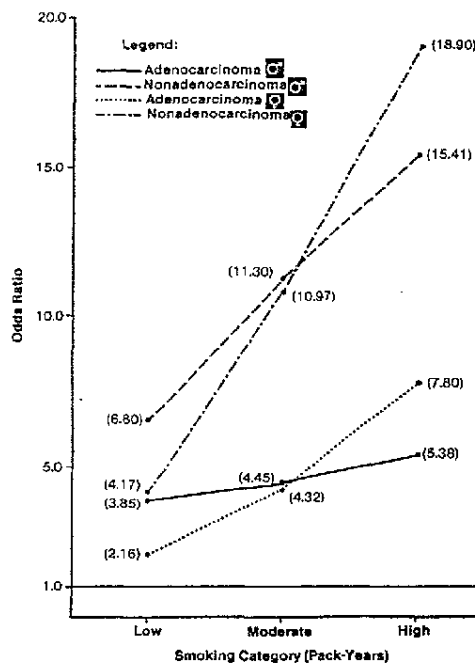


Figure 5. Odds ratios associated with smoking by lung cancer cell type.

The majority (approximately 60%) of the females reported their usual occupation as housewife. Using this category as the referent (OR = 1.0), smoking-adjusted odds ratios (ever/never) were calculated for the remaining categories (Table 14). Although there are several categories with elevated odds ratios, only the odds ratio for the clerical category (1.57) is significant. The odds ratio for the service category (1.57) is similarly increased, and of borderline statistical significance.

Table 12. Adjusted^a odds ratios for usual occupation in Texas male lung cancer study, 1976-1980

Occupation category	Total number in category (cases and controls)	Odds ratio	Confidence interval	χ^2
Clerical/Sales	94	0.61	0.36, 1.04	3.33
Service	50	1.12	0.60, 2.09	0.13
Agriculture	39	0.89	0.44, 1.84	0.09
Processing	77	0.80	0.47, 1.38	0.63
Machine trades	77	1.37	0.78, 2.39	1.19
Bench work	14	1.04	0.34, 3.19	0.01
Structural work	275	1.46	0.96, 2.20	3.15
Miscellaneous	140	0.89	0.55, 1.44	0.22
Professional/Technical	157	1.00	—	—

^a Adjusted for smoking (ever/never).

Table 13. Adjusted^a odds ratios for usual industry of employment in Texas male lung cancer study, 1976-1980

Industry category (SIC number)	Total number in category	Odds ratio	Confidence interval	χ^2
Agriculture (01-09)	30	1.64	0.70, 3.83	1.31
Oil/gas extract (13)	28	2.44	1.00, 5.97	3.82
Other mining (10-12, 14)	8	0.72	0.19, 2.80	0.22
Construction (15-17)	150	2.56 ^b	1.49, 4.41	11.50
Chemical (28)	60	2.16 ^b	1.10, 4.24	5.04
Petroleum (29)	178	1.54	0.91, 2.60	2.63
Metals (33-34)	25	3.38 ^b	1.36, 8.39	6.90
Shipbuilding (373)	27	1.91	0.83, 4.42	2.29
Other manufacturing (20-39 minus above)	52	1.55	0.77, 3.12	1.51
Transportation (40-49)	120	2.57 ^b	1.47, 4.52	10.88
Personal services (60-69, 80, 91-97)	65	1.73	0.91, 3.29	2.76
Professional/Governmental (70-79, 81-87)	85	1.34	0.73, 2.44	0.91
Sales (50-59)	97	1.00	— —	—

^aAdjusted for smoking (ever/never).^bp < .05Table 14. Adjusted^a odds ratios for usual occupation in Texas female lung cancer study, 1976-1980

Occupation category	Total number in category	Odds ratio	Confidence interval	χ^2
Clerical	161	1.57 ^b	1.07, 2.31	5.27
Service	88	1.57	0.96, 2.57	3.22
Agriculture	3	0.74	0.14, 3.92	0.12
Processing	2	4.22	0.43, 41.33	1.53
Machine trades	2	2.66	0.45, 15.93	1.15
Bench work	11	1.67	0.47, 5.97	0.62
Structural	2	5.22	0.79, 34.59	2.93
Miscellaneous	8	2.27	0.52, 9.98	1.18
Professional/Technical	110	1.15	0.75, 1.76	0.40
Housewife	551	1.00	— —	—

^aAdjusted for smoking (ever/never).^bp < .05

There were too few observations in the remaining categories for a meaningful analysis. A similar analysis of usual industry of employment for females indicated no categories of concern except for the possible exception of the increase noted for the category of other manufacturing (Table 15).

Smoking-adjusted odds ratios were also examined for the usual occupation and industry of employment for the spouses of both males and females. The only significantly increased odds ratio observed was for the usual industry of employment for spouses of female lung cancer cases. The Construction industry, with 146 cases and controls reporting this as the usual industry for their spouse, was associated with an increased odds ratio of 1.74 (1.04, 2.92; $\chi^2 = 4.40$).

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Table 15. Adjusted^a odds ratios for usual industry of employment in Texas female lung cancer study, 1976-1980

Industry category	Total number in category	Odds ratio	Confidence interval	χ^2
Agriculture	6	0.91	0.24, 3.53	0.02
Oil/gas extract	4	2.01	0.37, 10.84	0.66
Other mining	0	—	—	—
Construction	2	4.95	0.75, 32.69	2.76
Chemical	2	3.93	0.40, 39.06	1.37
Petroleum	6	0.43	0.91, 2.00	1.16
Metals	2	3.93	0.40, 39.06	1.37
Shipbuilding	2	3.93	0.40, 39.06	1.37
Other manufacturing	23	2.70	0.95, 7.67	3.50
Transportation	12	0.78	0.22, 2.76	0.15
Services	74	1.26	0.75, 2.13	0.75
Professional/Governmental	93	1.08	0.69, 1.69	0.12
Sales	113	1.23	0.80, 1.90	0.92
Housewife	592	1.00	—	—

^aAdjusted for smoking (ever/never).

Table 16. Odds ratios for household member regularly employed in specific industry for Texas lung cancer study, 1976-1980: Males

Industry	Yes		Odds ratio	95% Confidence interval	χ^2
	Case	Control			
Asbestos manufacturing	6	2	2.60	0.60, 11.25	1.76
Cement manufacturing	5	5	0.99	0.30, 3.25	0.00
Insulation manufacturing	4	1	2.99	0.47, 19.04	1.48
Coal mining	11	4	2.57	0.86, 7.71	3.06
Shipyard/shipbuilding	58	52	1.11	0.75, 1.65	2.27
Demolition	5	3	1.54	0.40, 5.93	0.41
High-rise construction	11	9	1.19	0.50, 2.84	0.16

Table 17. Odds ratios for household member regularly employed in specific industry for Texas lung cancer study, 1976-1980: Females

Industry	Yes		Odds ratio	95% Confidence interval	χ^2
	Case	Control			
Asbestos manufacturing	5	10	0.55	0.20, 1.50	1.29
Cement manufacturing	5	10	1.17	0.32, 4.25	0.21
Insulation manufacturing	9	4	2.24	0.73, 6.94	2.07
Coal mining	7	12	0.63	0.25, 1.57	1.00
Shipyard/shipbuilding	99	102	1.02	0.75, 1.39	0.02
Demolition	5	7	0.77	0.25, 2.33	0.02
High-rise construction	37	26	1.52	0.91, 2.55	2.60

In addition to these analyses specific questions were asked regarding whether anyone in the household ever worked in the following industries: asbestos, cement, or insulation manufacturing; coal mining; shipyards and shipbuilding; demolition;

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high-rise construction. For both males and females a large number of cases and controls reported having a household member employed in a shipyard or in shipbuilding, but this was not associated with an increased odds ratio (1.11 for males and 1.02 for females) (Tables 16 and 17). Among males there were no statistically significant increases; however, the odds ratios for asbestos manufacturing, insulation manufacturing, and coal mining are increased. Similarly, for females the odds ratio is increased for insulation manufacturing and high-rise construction but not significantly.

Discussion

The availability of fairly large numbers of male and female incident lung cancer cases and comparison subjects in an interview study with detailed occupational histories provides an important basis for examining the contribution of occupational exposures to lung cancer in males and females. Recognizing the strong increase in lung cancer risk associated with cigarette smoking, such analyses need to control for smoking differences. Our preliminary analysis of usual occupation and industry of employment with a broad smoking adjustment (ever/never) indicates several occupational and industrial associations that need to be pursued in future analyses. Specifically, odds ratios are significantly increased for usual employment in several industries (construction, chemical, metal, and transportation) for males and the clerical occupations for females. In addition, there are several associations suggested by increased odds ratios, which are not statistically significant. For males, an increased risk is suggested for occupations in the structural category and employment in industries related to oil and gas extraction (SIC 13), petroleum refining (SIC 60-69), and shipbuilding (SIC 373). For females, occupations in the service category and industries in the other manufacturing group are associated with fairly stable increased odds ratios.

Future analysis of these data will examine the possible interaction of smoking with occupational and industrial groups and a possible need to employ more specific smoking strata. Examination of odds ratios for smoking strata within occupational and industrial categories suggested that an ever/never smoking classification would be sufficient to control for the confounding effect of smoking in the examination of overall risks associated with usual employment in specific occupational and industrial categories as presented here. However, this broad classification may not be sufficiently specific for an examination of interaction of smoking with workplace exposures. In these analyses the classification of "exposed" within a specific category is based upon the "usual" occupation or industry of employment rather than "ever employed" in a given work environment. The use of the usual pattern may be more conservative in the detection of occupational and industrial associations and is perhaps the more appropriate designation to use for a preliminary examination of the data. As noted, the use of the usual occupation and industry of employment did introduce some special constraints on the analysis of the female patterns in that the usual occupation and industry for over

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60% of the cases and controls was "Housewife." We will employ a number of more specific designations of occupational and industrial variables in future analyses.

Even with these recognized limitations, the suggestion which clearly emerges from our data is that there may be a wider variety of workplace exposures associated with substantial increments in the risk of lung cancer than currently recognized. In addition, use of the full work history, including dates will surely aid in refining the preliminary associations reported here.

The relationship of lung cancer cell type with age at time of diagnosis warrants further scrutiny in that the highest odds ratios for the smoking variables were observed for the youngest age group (< 57 years at time of diagnosis). The lack of a "passive smoking" effect when the confounding effect of smoking of individual study subjects is considered, is not consistent with early reports. Although subsequent reports are also not consistent with regard to this association, it may be that the study population available was not sufficiently large to detect a fairly low level effect and that this association needs to be assessed in a considerably larger study population.

These preliminary analyses demonstrate a strong and consistent smoking effect in males and females for all types of lung cancer. The risk differentials associated with cigarette smoking observed for adenocarcinoma and other lung cancer cell types are striking and consistent with findings of others (11). In addition, they reemphasize earlier suggestions that perhaps specific environmental exposures are more strongly associated with specific types of lung cancer. In addition, these data suggest that perhaps lung cancer is more similar in males and females than previously regarded and that the observed differentials in risk by sex are principally due to exposure differentials.

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